Eastern Rivers and Mountains Network
Vital Signs Prioritization Workshop
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Large River Ecosystem Working Group
Final Report

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1. Work Prior to the Workshop

1a: A comprehensive list of potential vital signs (61 total) was received from the NPS ERM I&M coordinator for use in developing a prioritized list for inclusion into a large rivers monitoring program within the ERM Network.

1b. The candidate list of all vital signs was reduced to only those previously ranked by the NPS as having relevance to large river systems (36 total, see Table 1).

VS: 2, 4, 5, 6, 7, 11, 13, 14, 15, 16, 17, 18, 19, 23, 28, 29, 30, 37, 39, 40, 41, 42, 43, 45, 48, 49, 50, 52, 53, 54, 55, 57, 58, 59, 60, 61.

1c. A list of potential purposes for a riverine monitoring program was developed (see Table 2), and three individuals at the USGS Northern Appalachian Research Lab, Wellsboro, PA (William Lellis, Robert Ross, Martin DiLauro) reviewed and rated each vital sign based on ecological significance towards understanding riverine systems and the potential value to a monitoring program. The list was also sent to four individuals for additional review and comment (Bob Hilderbrand, U. Maryland; Karen Riva Murray, USGS; Paul Angermeier, Virginia Tech; Peggy Johnson, Penn State).

A literature review was conducted and a conceptual model developed based on concepts presented by James R. Karr in *Defining and measuring river health, Freshwater Biology (1999) 41:221-234* (see Fig. 1). The model is based on the concept that both natural factors and human activities affect the physical, hydrological, and chemical characteristics of the river. In combination, these abiotic factors shape the structure and distribution of biological communities, which can themselves be analyzed to infer the environmental conditions in which they live. Undesirable changes in biological communities would lead to policy or actions

intended to alter human activities that negatively impact the physical, hydrological, or chemical environment. This feedback loop was considered to be an important element of a monitoring program based on the assumption that the NPS would want to use monitoring information to protect and preserve park resources, rather than simply document change over time.

A short list of vital signs was then developed for consideration into a riverine monitoring program. The list was designed to include at least one indicator each of the geological, hydrological, chemical, and biological condition of the system; one indicator each of the most likely natural and human influences on the system; and one early warning indicator of potential health hazard to park visitors. Indicators were only considered in the context of the river systems within ERM network parks (DEWA, UPDE, NERI, GARI, BLUE). The short list was arbitrarily limited to 10 vital signs based on the assumption that rivers would only be a portion of the total monitoring program, and finances and manpower would be constrained. Relevance to all riverine parks was considered, and the riparian zone was considered part of the river system. Vital signs were not prioritized within this short list, outside of inclusion or non-inclusion. The 10 proposed vital signs are listed above the break line in Table 1.

Short List VS: 4, 7, 13, 16, 17, 28, 39, 45, 52, 57.

1d. Rationale for inclusion in the short list:

VS-7, river channel geomorphology: The most important geological determinant of river and riparian character that can be altered by natural and human influences. Of particular importance is sediment transport and deposition. Intended to be monitored at long intervals or after major events.

VS-13, surface water hydrology: The most important hydrological determinant of river and riparian character that can be altered by natural and human activities. Of particular importance to the ERM network due to water withdrawal, containment, and release from impoundments on mainstem and tributaries. Long-term data sets and ongoing monitoring programs by USGS.

VS-16, water quality core parameters: The most important chemical determinant of riverine character, largely altered by human activity. Core parameters are currently monitored at all parks through ongoing program.

VS-17, water quality expanded parameters: Indicators of specific human activities such as agriculture, development, and industry. Of particular importance is nutrient loading and fecal coliforms.

VS-39, aquatic macroinvertebrates: Most robust indicator of cumulative physical and chemical impacts on biological communities. Monitoring techniques are standardized and well-developed. Many matrices available. Ongoing federal and state programs.

VS-45, fish communities: Higher level indicator of biotic integrity. Also indicator of park natural resource usage and general detection of invasive species. Can be tied to contaminants and aquatic animal disease monitoring programs.

VS-28, riparian plant communities: Most important indicator of riparian zone biological integrity. Detection of riverine biodiversity. Particularly important in detection and monitoring of riverine invasive species.

VS-52, bioaccumulation of toxins: A practical means of monitoring toxic compounds and metals that exist in low concentrations or are pulsed through the ecosystem. Indicator of potential health risk to park visitors.

VS-4, weather and climate: The most important natural influence on riverine conditions. Long-term data sets available and ongoing federal and state monitoring programs. Data needed to separate natural variation from human-induced change.

VS-57, land cover and land use change: The most important human influence on riverine conditions in ERM parks outside of water management through impoundments. Changes in land use and development outside park boundaries are likely to have major impact on park resources over the next century. Parks will need this information to interact with local community planning boards.

Rationale for omission from the short list:

VS-2, air deposition: Potentially important source of inorganic pollutants to river systems, but probably less impact than point sources. Air deposition is likely more damaging to terrestrial and tributary systems than large rivers.

VS-5, phenology: Biological rhythms may be sensitive indicators of environmental change, but too little is known of aquatic cycles or natural variation within those cycles. More appropriate for directed study than monitoring.

VS-6, landslides: Landslides can alter channel geomorphology, water flow, and sedimentation patterns and thus may be important in understanding changes in river ecosystems. However, landslides and their impacts would likely be detected during geological (VS-7), water quality (VS-17), and perhaps land cover (VS-57) monitoring programs.

VS-11, soil erosion: Like the primary contributor of sediments in eastern river systems (along with bank erosion, and to a lesser degree, landslides), and thus is an important factor in understanding river ecology. However, the NPS may be better served by including a direct measurement of sedimentation into the monitoring program (VS-7, VS-17), then conducting source studies if unacceptable loads are detected.

VS-14, wetland hydrology: Wetlands were not considered by the river ecology group under the assumption that they would be addressed by either the terrestrial or tributary group.

VS-15, groundwater hydrology: Groundwater input is likely a very important component of eastern river ecology as a source of flow, nutrient input, and thermal refuge during winter and summer. However, ground water input and impact is very difficult and costly to quantify, and thus may be more appropriate for directed studies rather than inclusion into an overall river monitoring program.

VS-18, invasive species status and trends: From a biological perspective, invasive species are one of the most disruptive factors in eastern river ecology, and should thus be considered for inclusion in a monitoring program. Within ERM network parks, most recognized problematic invasives are either fish or riparian plants. VS-18 was not included in the rivers short list under the assumption that some information on these invasives would be obtained through inclusion of VS-28 and VS-45. A complicating factor in ERM parks is that many, if not most of the game fish are invasive species whose populations are managed and encouraged by state resource agencies for recreational fishing.

VS-19, invasive species early detection: Early detection of invasive species is both complicated from a program design perspective and expensive from a manpower perspective. VS-19 was not included in the rivers short list under the assumption that some new invasives may be detected through inclusion of VS-28, 39, and 45, and that early detection of invasives is more appropriately addressed through a stand-alone program than by inclusion in long-term monitoring.

VS-23, wetland plants: Wetlands were not considered by the river ecology group under the assumption that they would be addressed by either the terrestrial or tributary group.

VS-29, riparian birds: The rivers preliminary group was not aware of any specific issues related to riparian bird communities within ERM parks, nor how riparian birds could serve as general indicators of ecosystem status considering the multitude of factors outside the riverine environment that could affect population size and distribution of these transitory species.

VS-30, riparian mammals: The rivers preliminary group was not aware of any specific issues related to riparian mammal communities within ERM parks, nor how riparian mammals could serve as general indicators of ecosystem status. Mammal populations may be more appropriately studied through either inventory programs or targeted investigations.

VS-37, migratory animals: Several migratory fish are of interest to the Delaware River parks, such as eels, shad, and striped bass. However, population status and trends in the parks are poorly understood and a multitude of factors beyond the riverine environment may affect their distribution and abundance. More appropriate for study through either inventory programs or targeted investigations.

VS-40, freshwater mussels: May be an important indicator of water quality and can alter ecosystem function through filtration and energy partitioning. Mussel populations have been extensively studied in the Delaware River parks, but the amount of variance over time is unknown, and the causes and implications of fluctuations are too poorly understood to consider inclusion in a general monitoring program unless the purpose is to simply document status and trends for future reference. Freshwater mussels (specifically *Elliptio complanata*) may be considered a "keystone species" in some ERM parks due to abundance and potential ecological impact. Mussels could be incorporated into a contaminants monitoring program (VS-52).

VS-41, crayfish: The rivers preliminary group was not aware of any specific issues related to crayfish communities within ERM parks, nor any work using crayfish as general indicators of ecosystem status. Crayfish may be important to riverine ecology due to benthic foraging behavior, but causes and implications of population variation over time are poorly understood. There is potential concern for spread of the invasive rusty crayfish into ERM parks, but monitoring may accomplished through VS-39 or VS-45.

VS-42, aquatic periphyton: Benthic algal communities may be sensitive indicators of human impact to eastern rivers due to their abundance in lotic systems, immobility, and adaptability to a wide range of ecological conditions. Although they have potential as a powerful tool in aquatic monitoring programs, they were not included in the riverine short list because less research has been done to develop regional or basin level metrics or to test dose-response gradients to human influence than have been developed for macroinvertebrate (VS-39) and fish (VS-45) communities.

VS-43, macrophytes: The rivers preliminary group was not aware of any specific issues related to macrophyte communities within ERM parks. Macrophyte density and distribution tends to fluctuate extensively in ERM parks both intra- and inter-seasonally, making a general monitoring protocol difficult to design and interpret. Biological response to aquatic conditions might better be monitored through VS-39 or VS-42.

VS-48, reptiles and amphibians: The rivers preliminary group was not aware of any specific issues related to reptile and amphibian populations within the rivers of ERM parks. The causes and ramification of a widespread decline in amphibian populations is of national interest, but more appropriately addressed by the terrestrial or tributary monitoring groups.

VS-49, State T&E species: The rivers preliminary group felt that endangered species issues would be more appropriately addressed through park-specific population studies than through a general monitoring program.

VS-50, Federal T&E species: The rivers preliminary group felt that endangered species issues would be more appropriately addressed through park-specific population studies than through a general monitoring program.

VS-53, fish and wildlife harvest: Not included in short list because of assumption that wildlife harvest is regulated, licensed, and monitored by the States. Much of the targeted fish harvest is invasive species (smallmouth bass, walleye, rainbow trout, brown trout). Specific concerns such as commercial eel harvest in the upper Delaware River are better addressed through park-specific projects rather than through a general monitoring program.

VS-54, visitor usage: Impacts by rafters, canoeists, boaters, swimmers, and fishers can be significant in the ERM parks, but VS-54 not included in short list because of assumption that visitation rates and patterns are tracked through other NPS programs, and impacts such as pollution or siltation would be more directly measured through VS-17.

VS-55, natural sounds: The rivers preliminary group was not aware of any specific ecological issues related to human-generated noise associated with rivers of ERM parks. There may be impacts of noise from river users, airplanes, and trains on the quality of experience by park visitors engaged in riverine activities, but these are better addressed by other NPS programs, such as the Soundscape Program.

VS-58, landscape pattern: Landscape pattern was understood by the rivers preliminary group to refer to patch size and distribution of dominant land cover types, which is of more importance to terrestrial and tributary ecology than to riverine ecology, which would be more influenced by land use and cover (VS-57). However, use, pattern, and cover may be viewed as different analyses of the same data sets, and thus VS-57 and VS-58 might be combined into one vital sign.

VS-59, primary productivity: Accurate and comprehensive calculation of primary productivity for riverine systems of ERM parks was seen as beyond the scope of a general monitoring program and better addressed through stand-alone projects.

VS-60, decomposition: Accurate and comprehensive calculation of decomposition rates in riverine systems of ERM parks was seen as beyond the scope of a general monitoring program and better addressed through stand-alone projects.

VS-61, nutrient dynamics: Components of interest to ERM parks are already addressed in VS-17.

2. Workshop.

2a. Draft narratives were prepared for some of the priority vital signs and distributed to the riverine panel prior to the workshop. Draft narratives did not completely match the preliminary list of priority vital signs due to final adjustments made to the list just before the workshop resulting from input received from external reviewers (see section 1c).

The workshop began with general introductions and goals by the ERM I&M Coordinator followed by break-out of focus groups. The riverine panel began with participant introductions and a discussion of the conceptual model used to prioritize vital signs. A preliminary short list was presented to the panel with an explanation and group discussions of why each vital sign was selected for the list. No vital signs were removed from the short list as a result of this process.

2b. Each vital sign not selected for inclusion in the short list was discussed in detail and group consensus was reached on whether those vital signs should or should not be included in the short list. This process resulted in an additional four vital signs being moved into the short list that were previously omitted (final list 14 total, see Table 3).

Additional VS: 15, 41, 42, 43.

VS-15, groundwater hydrology: Moved to short list because of importance to river ecology and potentially significant impacts from predicted development outside park boundaries. However, monitoring proposed only to the extent that data can be obtained from other agencies, not seen as an NPS-funded project due to projected expense.

VS-41, crayfish: Moved to short list because of potential importance to benthic community structure and rapidly spreading distribution of invasive rusty crayfish poised to enter eastern parks.

VS-42, aquatic periphyton: Moved to short list because of recent work by EPA and others in developing sensitive metrics applicable to ERM parks.

VS-43, macrophytes: Moved to short list because macrophytes may be a better indicator than other biological communities of nutrient enrichment and sedimentation released from upstream impoundments.

2c. Each panel member was then asked to anonymously rate each of the 14 vital signs as to whether it should be ranked as Tier-1, 2, or 3, with Tier-1 being highest priority for inclusion into a monitoring program to detect changes in river ecology and identify cause of change, Tier-2 being important additional information helpful but not critical to understanding river ecology, and Tier-3 being important to understanding certain park-specific ecological issues, but not critical to all parks in the ERM network. Vital signs were then ranked based on the sum total of Tier rankings by each of the 15 panel members (see Table 4).

VS Ranking: 16, 39, 45, 13, 57, 17, 42, 7, 4, 52, 28, 41, 43, 15.

2d. Final classification into Tier-1, 2, and 3 ranking was done by group discussion and consensus based on sum, mean, and proportion of votes for each rank. Following presentation to the entire group and overnight deliberations, the panel reviewed the Tier rankings and made final adjustments based on group consensus without the need for additional individual voting (see Table 4).

Tier-1 VS: 16, 39, 45, 13, 57.
Tier-2 VS: 17, 42, 7, 4, 52, 28.
Tier-3 VS: 41, 43, 15.

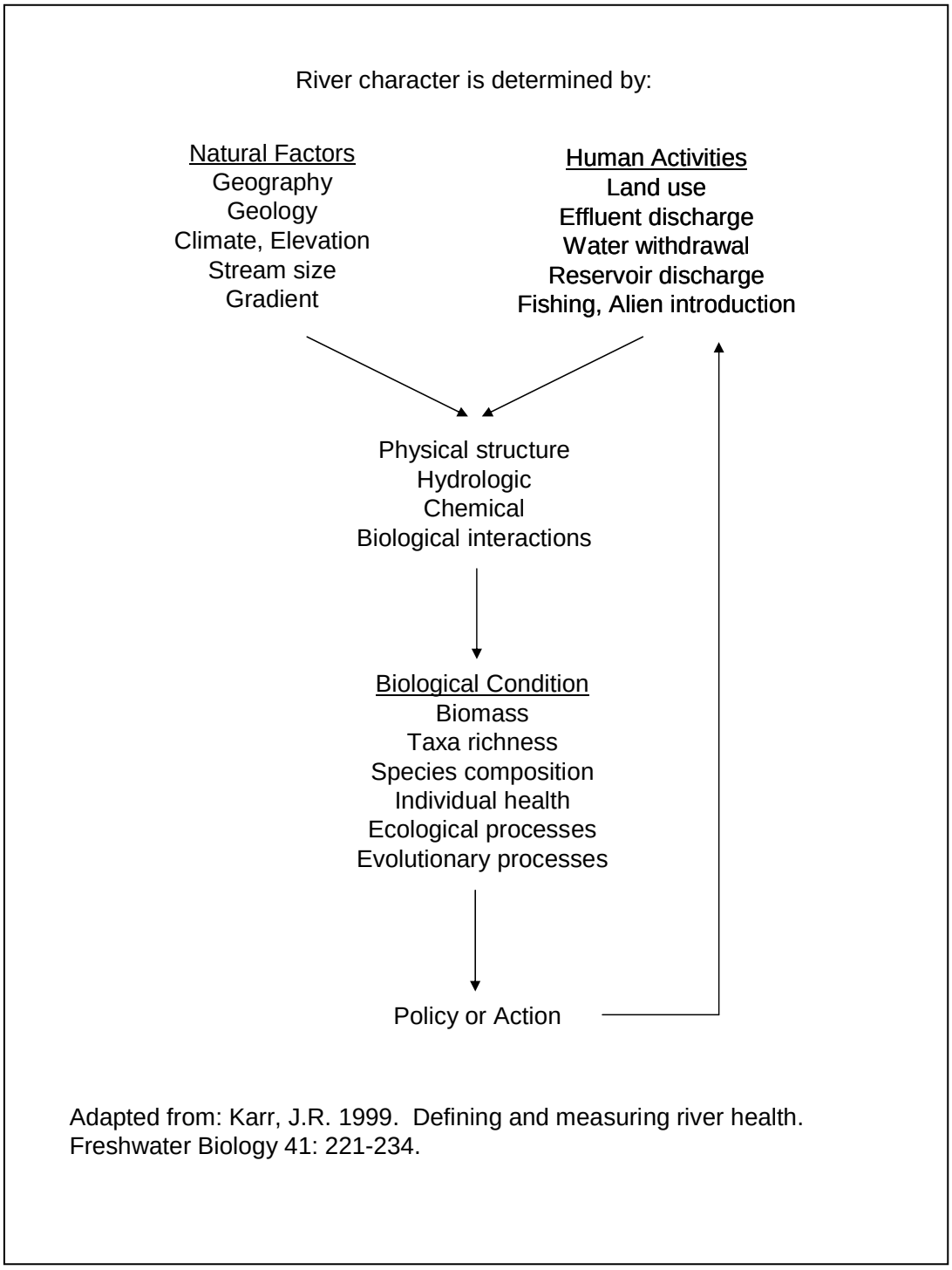
Table 2. Potential purposes of a large river monitoring program.

1. Document current condition.
2. Monitor change over time.
3. Evaluate human impact.
4. Determine sources of impacts.
5. Monitor specific know stressors.
6. Monitor predicted future stressors.
7. Monitor biological condition.
8. Monitor keystone species.
9. Monitor target species of interest.
10. Monitor threats to park visitors.

Table of Workshop Rankings

Rank	VS#	Vital Sign	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Sum	Mean	T-1	T-2	T-3	Tier
1	16	Water quality core	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	16	1.07	14	1	0	1
2	39	Macroinvertebrates	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	16	1.07	14	1	0	1
3	45	Fish communities	1	1	1	1	1	2	1	1	1	1	1	1	1	1	3	18	1.20	13	1	1	1
4	13	Surface hydrology	1	2	1	2	1	1	1	1	1	2	1	1	2	2	1	20	1.33	10	5	0	1
5	57	Land use/cover	1	2	2	2	2	1	2	2	1	2	1	1	1	1	2	23	1.53	7	8	0	1
6	17	Water quality expanded	2	2	2	1	1	1	2	2	1	2	1	3	1	2	1	24	1.60	7	7	1	2
7	42	Periphyton	3	1	2	2	3	1	2	2	2	2	3	1	1	1	2	28	1.87	5	7	3	2
8	7	Geomorphology	3	1	2	3	3	2	2	2	2	3	2	1	1	3	3	33	2.20	3	6	6	2
9	4	Weather and climate	1	3	3	3	2	2	3	3	2	1	2	1	2	2	3	33	2.20	3	6	6	2
10	52	Bioaccumulation	2	3	3	1	1	3	3	2	2	3	1	3	2	3	2	34	2.27	3	5	7	2
11	28	Riparian plants	3	3	2	3	3	2	1	3	2	2	2	2	2	3	2	35	2.33	1	8	6	2
12	41	Crayfish	3	2	3	1	1	3	3	3	2	2	3	2	2	2	3	35	2.33	2	6	7	3
13	43	Macrophytes	3	3	2	3	2	3	3	2	2	2	3	1	2	2	3	36	2.40	1	7	7	3
14	15	Groundwater hydrology	1	3	2	3	3	3	2	3	2	3	3	1	2	3	3	37	2.47	2	4	9	3

Figure 1. Conceptual model for prioritizing vital signs for large river ecosystems.



Adapted from: Karr, J.R. 1999. Defining and measuring river health. Freshwater Biology 41: 221-234.